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# COMPOSITE TEMPERATURE TYPES OF THE UNITED STATES*

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In a broad study of the essential characteristics of temperature over an extended area such as that of the United States, the conventional "typical" diagrams showing the annual march of temperature at certain selected stations are not wholly satisfactory. Such curves illustrate conditions which are often representative of small districts only. They not infrequently emphasize somewhat too strongly the local controls and peculiarities at individual places. They inevitably become associated with the names of the particular stations whose conditions they represent and may thus fail to bring clearly before the mind the larger and more general conditions which characterize broad areas.

## Composite Temperature Curves

In his own teaching of college students the writer has found it useful to employ, in addition to the temperature curves for individual stations, *composite* curves showing the annual march of temperature as illustrated by the mean monthly values summarized for a group of stations in the same general region or climatic province.

The following diagrams, here published for the first time, are used for purposes of instruction in the course on the climatology of the United States which has been given at Harvard during the past twenty years. Familiarity with these fundamental curves enables anyone to answer reasonable questions regarding the march of temperature in any part of the United States and also to name the climatic province in which an unknown station whose monthly temperatures are given is situated. These curves are constructed as follows. For each climatic province a representative series of stations is selected, ranging in number from ten to fifteen or twenty. In the majority of cases these are regular Weather Bureau stations, because they have the longest records and show conditions over the districts of densest population. Most of the places selected are fairly near sea level, but in the western mountain and plateau districts several of them are

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* This is the eighth in a series of articles by the present writer on the climatology of the United States. The previous articles were: Climatic Subdivisions of the United States, *Bull. Amer. Geogr. Soc.*, Vol. 47, 1915, pp. 672–680; Rainfall Types of the United States, *Geogr. Rev.*, Vol. 4, 1917, pp. 131–144; Rainy Days and Rain Probability in the United States, Vol. 7, 1919, pp. 44–48; Frost in the United States, *Geogr. Rev.*, Vol. 7, 1919, pp. 339–344; Cloudiness in the United States, *Geogr. Rev.*, Vol. 9, 1920, pp. 347–356; New Monthly and Seasonal Rainfall Maps of the United States, *Geogr. Rev.*, Vol. 10, pp. 173–181; A New Series of Sunshine Maps of the United States, *Geogr. Rev.*, Vol. 10, pp. 339–341.

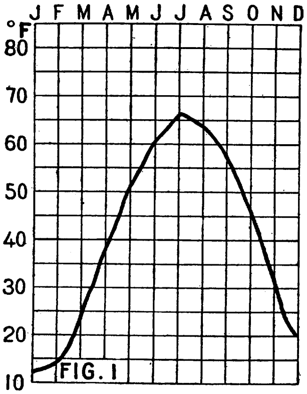
5,000 or more feet in elevation. In addition, the data for certain co-operative stations with long records are included, in order that the temperature in localities where there are no regular Weather Bureau stations may have representation. Altitudes above those of considerable human settlement are, however, not taken into account. More co-operative observers' records are used in the west than in the east. The data have not been reduced to a uniform basic period. Such reduction is unnecessary when observations for several stations, at various altitudes and with diverse topographic environment, are included in one general summary. The data employed are the latest and best available.

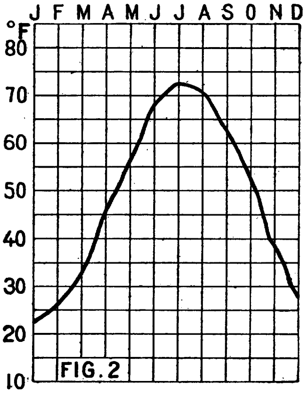
## PURPOSE OF THE COMPOSITE CURVES

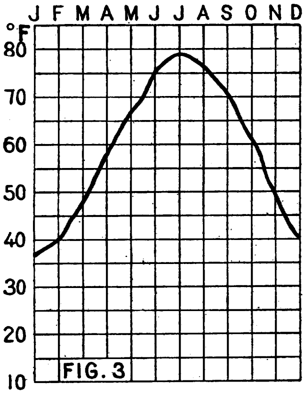
Composite curves of the kind here given are very satisfactory for the purpose for which they are intended to be and have been employed, i.e. to bring out the larger facts of temperature over considerable areas. The objection that these curves do not illustrate the actual conditions at any place and that they are therefore simply a "hodgepodge," is not valid when the specific purpose of the diagrams is considered. They are not intended to show the exact temperatures at any station. If it were desired to illustrate, e.g., the local conditions on mountains, in valleys, by the sea, around the Great Lakes, etc., an almost indefinite number of curves would be needed which, however interesting and important in themselves, would not be useful in any general study which must be completed within a limited time. Anyone who seeks such specific and exact information can find it in the very complete tabulations of data in *Bulletin W* and in other publications of the Weather Bureau. In *Bulletin W* the data for most of the 106 "sections" are grouped according to the natural topographic or other subdivisions (usually three or four) of each section. If a curve were drawn for each subdivision of all of the 106 sections, it can readily be seen that the number of such curves would run up to several hundred. The gain in simplicity which results from the use of a few composite curves such as those here given far more than offsets, in the opinion of the writer, the disadvantage that these curves do not represent any specific places. In the composites here given, representative data have been included for each of the more important subdivisions given in *Bulletin W*. This bulletin sets forth many facts of essential importance in any detailed study of temperature. The stations are grouped by counties as well as, in most cases, by climatic subdivisions; the altitudes are given, and a contour map for each section shows the exact location of each station and its general topographic surroundings.

## CLASSROOM USE

In the use of these composite curves in the classroom, the logical method is first to familiarize the students with the curve for each large climatic province, as an illustration of the general conditions, and then to indicate,







FIGS. 1–12—Annual march of temperature by months for the climatic provinces of the United States.

FIG. 1—Eastern province, northern tier. Mean annual 40° ±; range 55° ±.

FIG. 2—Eastern province, central tier. Mean annual 50° −; range 50° −.

FIG. 3—Eastern province, southern tier. Mean annual 60° −; range 40° +.

verbally or by means of numerical data, how the conditions in the north and south, or on the mountains, or near the sea, differ from the composite. By following such a method the number of general temperature types remains relatively small and yet serves as the foundation upon which variations from the composite may be built up. The composite is the pattern. The departures from it are embroideries upon that pattern. It is important that all the curves be plotted on the same scale, and on co-ordinate paper slips of uniform size. By this method the differences in the monthly and annual temperatures themselves, and also the differences in the amounts of mean annual range, are clearly seen, and the larger effects of land and water are emphasized.

## THE EASTERN PROVINCE

The Eastern climatic province extends from the Great Plains eastward to the Atlantic and southward to the section bordering on the Gulf of Mexico. Latitude, not altitude, is the fundamental control of temperature. Hence it is both logical and convenient, for the present purpose, to give three composite curves for this province, each curve representing an east-west belt of about 5° of latitude in width. The first of these (Fig. 1) is for the (a) *northern tier*, north of latitude 45° N., which extends from eastern North Dakota (including northeastern South Dakota) eastward across Minnesota and then across the northern portions of Wisconsin, Michigan, and New England. The second (Fig. 2) is for the (b) *central tier* of states, between latitudes 40° and 45°, lying between the eastern margin of the Great Plains and the Atlantic. The third (Fig. 3) is for the belt between latitude 40° on the north and the Gulf province on the south, and extends from the Great Plains to the Atlantic. This may be called the (c) *southern tier*.

Figures 1, 2, and 3 may best be considered together. The mean annual temperatures and the mean annual ranges are given in round numbers below the curves. All three curves are distinctly continental in character. January and July are the coldest and warmest months respectively, and the annual ranges are large. From north to south the (composite) mean annual temperatures increase from about 40° to slightly below 60°, which is at the rate of about 10° for 5° of latitude, and the (composite) mean annual ranges decrease from about 55° to slightly over 40°. The increasing mildness of the winters and the increasing heat of the summers from north to south also appear distinctly in the differences in the position of the three curves on the co-ordinate base. From the fact that each of the three "tiers" covers a range of 5° (in the northern tier it is 5°−; in the southern tier it is 5°+) it follows that the northern stations will have colder winters and lower mean annual temperatures than the stations in more southern latitudes in the same tier. Thus the January means at the northernmost stations are in some cases as much as 10° (more or less) lower than those shown in the curves, and the southernmost January means are higher than those of the curves by the same amount or less.[1] Among the special characteristics which distinguish the temperature curves in different portions of the Eastern province, the following may be noted. It is a rather striking fact that the temperature conditions between the middle or even the western portions of the individual belts do not differ very greatly from those in the east, in spite of the considerable longitudinal extent of the belts. The reason is found in the fact that, chiefly under the control of the prevailing winds, the continental climate of the interior reaches the Atlantic Ocean. It is true, as has been pointed out, that the winters of the northernmost interior are colder than those farther south in the same belt; but if we take a belt of country like that between Chicago and Boston, for example, which the writer has for convenience described as the "New York Central belt," it is found that the mean annual and the mean monthly temperatures are essentially the same all along this belt. If a class of students be given the monthly means for Chicago, Cleveland, Albany, and Boston, e.g., without any indication of the names or the location of these four stations, it will, at any rate in the earlier stages of such a study, be found difficult if not impossible for the individual members of the class to determine whether the particular station in question is in New England or in New York or as far west as Chicago. Increasing familiarity with temperatures will, however, soon lead a class to distinguish between the somewhat colder winters of the farther western stations and the slightly milder winters on the Atlantic coast. Another special modification of the composite curves shown in Figures 1 and 2 appears around the Great Lakes, where "marine" influences at certain stations result in somewhat tempered winters and in a retarded minimum, February being either slightly colder than January or the two months having nearly the same mean temperature. A third modification, of a more local type, is seen in the cooling influence of the Atlantic Ocean

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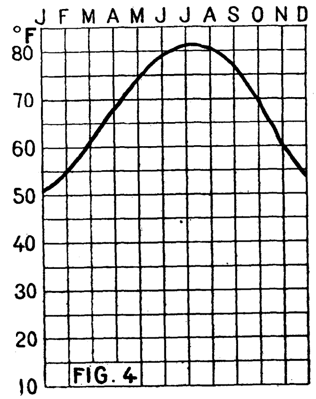
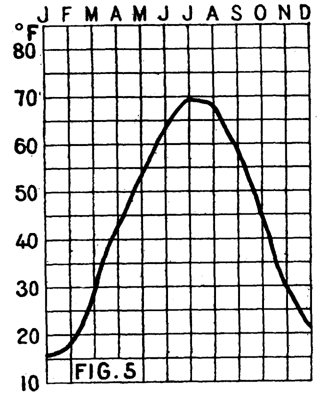
[1] "Northernmost" and "southernmost" refer to the most northern and most southern of the group of stations selected to make up the composite curve.





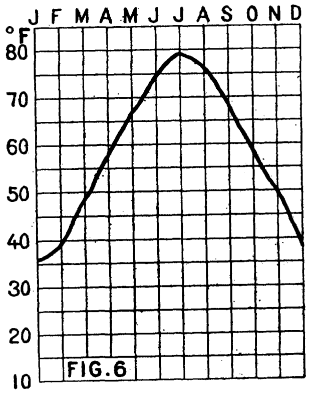


Fig. 4—Gulf province. Mean annual 70° −; range 30° ±.

Fig. 5—Northern Plains province. Mean annual 45° −; range 55° −.

Fig. 6—Southern Plains province. Mean annual 55°–60°; range 40° +.

at certain coast stations during midsummer. The coast of Maine is especially favored in this respect. Again, the modifying influence of altitude may be seen in the annual march of temperature at many stations scattered throughout the Appalachian area, from New England southward.

## The Gulf Province

Figure 4, which gives the composite curve for the districts bordering on the Gulf of Mexico and on the adjacent portion of the Atlantic (Gulf province), should be taken as part of the sequence already discussed in the preceding paragraphs.

The Gulf province is, obviously, only a fourth—the southernmost—tier of the Eastern province taken as a whole. From north to south the mean annual temperatures of these four belts are seen to increase about 10° from one tier to the next. The Gulf province thus has a composite mean annual of slightly below 70°. Its range is also about 10° less than that shown in Figure 3. The increasing mildness of the southern winters (individual January means are slightly over or under 50°) and the somewhat higher summer temperatures (July and August means are usually within a degree or so of 80°) are characteristic features. It will also be noted that August differs less from July than is the case in the preceding composites. The prevalence of on-shore winds along the southern coast during the summer months, together with the resulting partial marine control, doubtless explains this condition.

## The Plains Province

The climate of the Great Plains differs from that of the eastern United States in rainfall rather than in temperature. The temperatures are here illustrated by two composite curves, one for the Northern and one for the Southern Plains. The line of division between the two roughly follows latitude 40°. Figure 5 shows the conditions based upon the data for a number of stations in Montana, eastern Wyoming, and the western portions of the two Dakotas and of Nebraska.

Figure 5 is very similar to Figure 1 but has slightly warmer summers, the composite mean annual range, expressed in round numbers, being about the same. At the Northern Plains stations, however, e.g. in North Dakota, the ranges are larger (over 60°) and the January means are 10° or so lower than those of the composite. At other stations, especially those farther south, the midwinter means are 5° or so above the composite means. There is, also, a variation of 5°–10° in the mean annual temperatures, according to the location of the individual stations. The rapid rise of temperature in spring, the fairly close similarity of the July and August means, and the rapid fall after the heat of the summer is over are noticeable. The warm summers of this great interior region of cold winters are an important climatic asset in relation to crop growth.

The Southern Plains (Fig. 6) have higher mean annual temperatures (55°–60° as against 45°−), smaller ranges (40°+ as against 55°−), much milder winters (warmer by about 15°–20° on the average in January), and somewhat warmer summers (July mean about 10° higher) than the Northern Plains. Comparing Figure 6 with Figure 4 (Gulf) it is seen that the latter has warmer winters, slightly warmer summers, and a smaller mean annual range. There is, however, naturally a very close correspondence between the Southern Plains province (Fig. 6) and the southern tier of the Eastern province (Fig. 3). The effect of latitude within the limits of the Southern Plains province is shown in the colder winters and lower mean annual temperatures at the northern stations. In the south, July means of 80° and slightly more occur.

## THE PLATEAU PROVINCE

The curves for the northern and southern portions of the Plateau province are necessarily based upon data from stations differing greatly in their topographic environment and altitude. Individual localities therefore show considerable departures from the general means shown in these diagrams. Into the details of such variations the present discussion cannot attempt to go. If a very rough generalization is desired, it may be stated that there may be a variation of 5°, plus or minus, in the annual, January, and July means from those shown in the composite. A comparison of Figure 7 with Figure 5 (Northern Plains) shows that the latter district, east of the Rocky Mountain barrier, has colder winters, lower mean annuals, and larger ranges, while the summers are practically the same. The central tier of the Eastern province (Fig. 2) has a very similar curve to that of Figure 7, but the latter has milder winters and a smaller range.

The Southern Plateau province includes so great a range of latitude (nearly 10°) and so varied a topography that a single composite curve is of little significance. The more northern, and the higher, stations differ greatly from those on the low-lying deserts to the south in the summer "heat

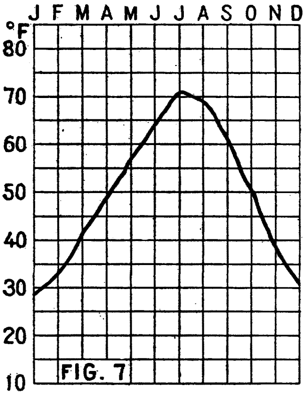


FIG. 7

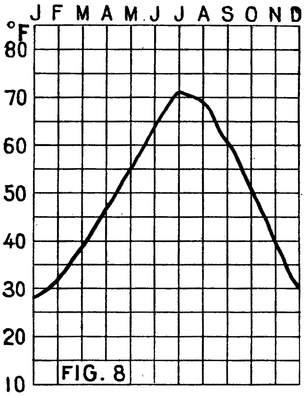


FIG. 8

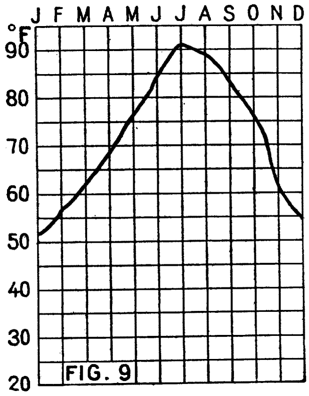


FIG. 9

FIG. 7—Northern Plateau province. Mean annual 50° +; range 40° +.

FIG. 8—Southern Plateau province. Mean annual 50° ±; range 40° +.

FIG. 9—Southern Plateau (southern desert lowlands) province. Mean annual 70° +; range 40° —.

island" of this interior region. The data used in the construction of Figure 8 do not include the latter group of stations. It is at once seen that Figures 7 and 8 are practically identical, as is to be expected when Figure 8 includes only such stations as are in the northern portion of the Southern Plateau and at considerable altitudes. This general fact is worth bringing out. There are stations over the Plateau whose mean annual and mean monthly temperatures are very similar to those of stations in the central tier of the Eastern province, but the other climatic characteristics are quite different.

Stations in the low-lying and arid "heat island" of southern Arizona have quite a different temperature curve from the composite of Figure 8. Figure 9 is based on the data for certain well-known and representative stations in southern Arizona. (In this diagram, the scale is the same as in the other figures, but the position of the individual temperature readings on the co-ordinate paper has been changed in order to accommodate the higher summer means.) The winters on the southern "deserts" are decidedly milder and the summers hotter than is the case at the stations situated in the north and on the elevated plateaus. Thus, the mean annual temperatures at the southern localities are about 70°, and the July means reach and even slightly exceed 90°. There is little likelihood of confusing the temperatures in southern Arizona with those of the Gulf province (Fig. 4). The former has distinctly hotter summers, although the annual means are more or less the same.

## THE PACIFIC PROVINCE

For the purpose of the present discussion the Pacific slope is conveniently subdivided into (1) Northern and (2) Southern Pacific provinces, and the latter into (a) coast and (b) interior valley. Many other local peculiarities of temperature distribution would appear if further subdivision were attempted, but the resulting increase in the number of composite curves would offset the object which the writer has in mind.

The curve for the Northern Pacific province (Fig. 10) is based upon data for the coast, the Puget Sound region, and the interior valleys. In the north, the temperatures in the longitudinal valleys do not differ as much from those of the coast and of the Sound as do those of the Sacramento-San Joaquin valley, farther south, from the temperatures of the southern coast stations. Hence, it does not seem necessary, in a very general consideration such as that in hand, to make more than one curve for the Northern Pacific climatic province. The summers of the interior valleys, e. g. especially in southern portions of Oregon, are, however, naturally warmer by several degrees than those of stations like Seattle or Tacoma. The composite curve (Fig. 10) at once shows the marine influence on a windward coast. The winters are milder than those shown on any of the preceding curves except in the Gulf province (Fig. 4) and on the desert lowlands of southern Arizona (Fig. 9) but are not unlike those of the southern tier of the Eastern province (Fig. 3) and of the Southern Plains (Fig. 6) so far as the mean temperatures alone are concerned. The summers average cooler than those in any of the preceding curves, even than those of the northern tier of states in the Eastern province (Fig. 1). The range (about 25° only) clearly indicates the equability of the Pacific slope climates. The departures, at individual stations, of the annual and of the January means from those shown on the curve are too small to call for comment. The July means differ by roughly about +5° (in the southern interior valley of Oregon) to about −5° (on the extreme northwestern coast).

A composite of the Southern Pacific coast conditions is given in Figure 11. The stations included in the composite are nearly all south of San Francisco. Here are the most equable temperatures shown in any of the curves. The

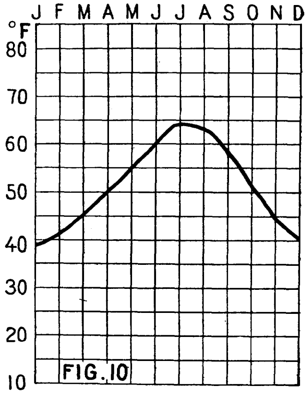


FIG. 10

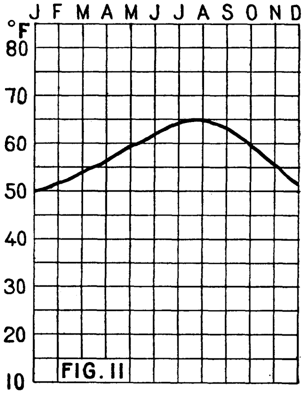


FIG. 11

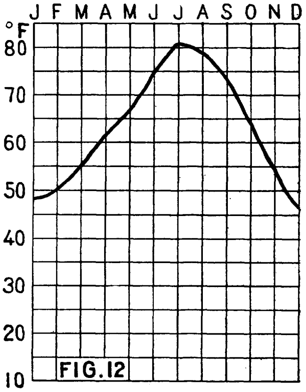


FIG. 12

FIG. 10—Northern Pacific province. Mean annual 50°+; range 25°±.

FIG. 11—Southern Pacific (coast) province. Mean annual 55°–60°; range 15°.

FIG. 12—Southern Pacific (interior) province. Mean annual 60°–65°; range 35°±.

range is only about 15°, and the monthly means are all included between 50° and 65°. The retardation of the maximum into August is seen at several, although not at all, of the coast stations and is sufficiently frequent to appear on the composite. This is distinctly a marine characteristic. On the extreme northern coast of California the mean annual temperature is a few degrees lower than that of the composite curve, and on the extreme southern coast it is about the same amount above the general mean.

Figure 12 is based on the data from about a dozen stations in the Sacramento-San Joaquin valleys. It is not unlike that for the Gulf province (Fig. 4); but the mean annual temperature is higher, and the range is smaller in the latter. The July means in the California valley are higher than those seen in any other curve except that for the Gulf (Fig. 4) and that for the "heat island" (Fig. 9) but are only slightly above those of the southern tier of the Eastern province (Fig. 3). A natural comparison is that between the coast and the interior of California (Figs. 11 and 12). The continental controls in the latter are obvious. In the interior July is the warmest month, as contrasted with the (frequently) retarded maximum in August on the coast. The winters are milder on the coast, and the summers decidedly cooler. Hence the mean annual range in Figure 12 is decidedly greater (by about 20°) than that in Figure 11. The Northern Pacific coast winters (Fig. 10) are not quite as mild as those of the California valley, as is to be expected from the higher latitudes and other controls in the former case; but the summers of the Northern Pacific are decidedly cooler than those of the southern interior valleys. In spite of the great extent of the California valley in a north-south line, the temperatures are remarkably uniform throughout the district. The maximum departures from the composite means are somewhat less than + 5° at the southern stations in July. The foothills of the Sierra Nevada have their own type of temperature curve, their cooler summers as compared with those on the valley floor being a valuable asset in the popularity of that district for summer outings.

## CONCLUSION

In conclusion it may not be inappropriate for the writer to state what, in his experience, has proved to be an effective way to fix in the minds of students the essential facts regarding the temperatures of the United States. The stages in the successive laboratory exercises on this subject are as follows:

1. A study of the larger world relations of the sea-level temperatures over North America, based on the *Challenger* isothermal maps.
2. A critical comparative study of the advantages and disadvantages of sea-level and of actual temperature charts for the United States, based on various maps, e.g. those of the *Challenger* series, of Hann, of the Weather Bureau, of Herbertson, and of others.
3. The students are given, in three weekly exercises, the mean monthly

temperatures at certain selected stations whose location is unknown to them. These temperatures are plotted by each member of the class on co-ordinate paper slips similar to those used in the present discussion, and then each student indicates, as well as he can, the probable location of each station. The material used in working out these locations is that which is already familiar through the preceding exercises. When each student has located the stations to the best of his ability, the names and exact locations are given. The curves are then attached, by means of paper fasteners, to a large wall outline map of the United States, mounted on a soft-pine frame to which it is fastened by thumb tacks. The students put the curves onto the outline map themselves, and a stimulating rivalry is created by the teacher's selecting those curves which are most neatly and most accurately plotted for use on the wall map. When all the curves have been plotted and fastened to the outline map, the latter is uniformly covered, and the temperatures over all parts of the country can be further compared and memorized. The whole exercise never fails to interest the class, and while it is in progress there is always much animated discussion as to the probable location of the different stations whose monthly temperatures have been given.

4. The composite curves included in the present paper are used, at the end of the laboratory exercises just described, for the purpose of summarizing, in a very broad and general way, the essential facts of the distribution and characteristics of the temperatures in the different climatic provinces of the United States.